Radio Testbeam Experiment T926

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1. What and Why
2. Experiences
3. Preliminary Results

THANKS

Magnificent work creating new test beam facility
…and such helpful folks!

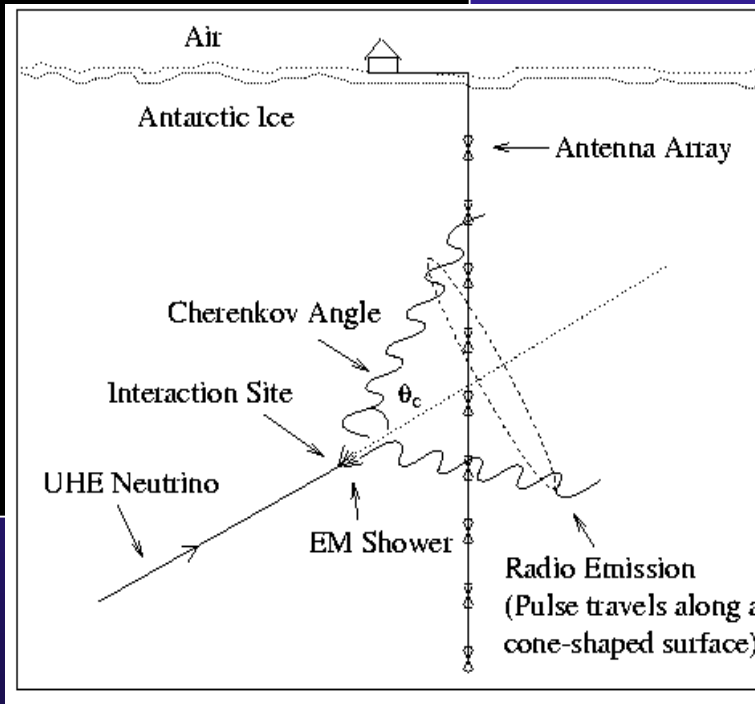
- Erik Ramberg!!!!!!!!!
- Chuck Brown
- Craig Moore
- Gordon Koizumi
- Al Russell
- Paul Allcorn
- Brian Chase
- Aria Meyhoefer
- Jeff Appel
- And I'm sure many others

What and Why: Radio Detection

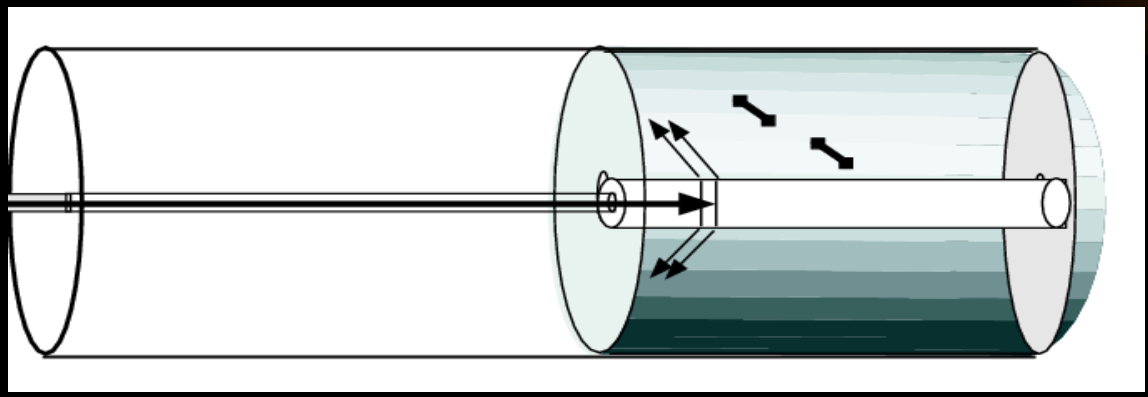
- Antenna sees electric field of moving charge Q at impact parameter b (ideal solution):

$$E_{T,max}(b,z=0,t=0) = \gamma Q/(4\pi\varepsilon b^2)$$

- RICE antennas look for ultra-high energy neutrinos in ice at South Pole.
- Intrinsic interest:
  - Novel measurement technique for beams
  - Understand properties of hadronic interaction calibration for RICE



Set-Up



Exploit relativistic cylindrical geometry

Aluminum tube:

- fixes boundary conditions
- shields noise
- known cavity modes
- cut-off low frequencies (no 53 MHz, in principle)

Set-Up (2)

Step 1 Noise Studies : NOISE at FNAL O(30mV)
LARGE, it turns out

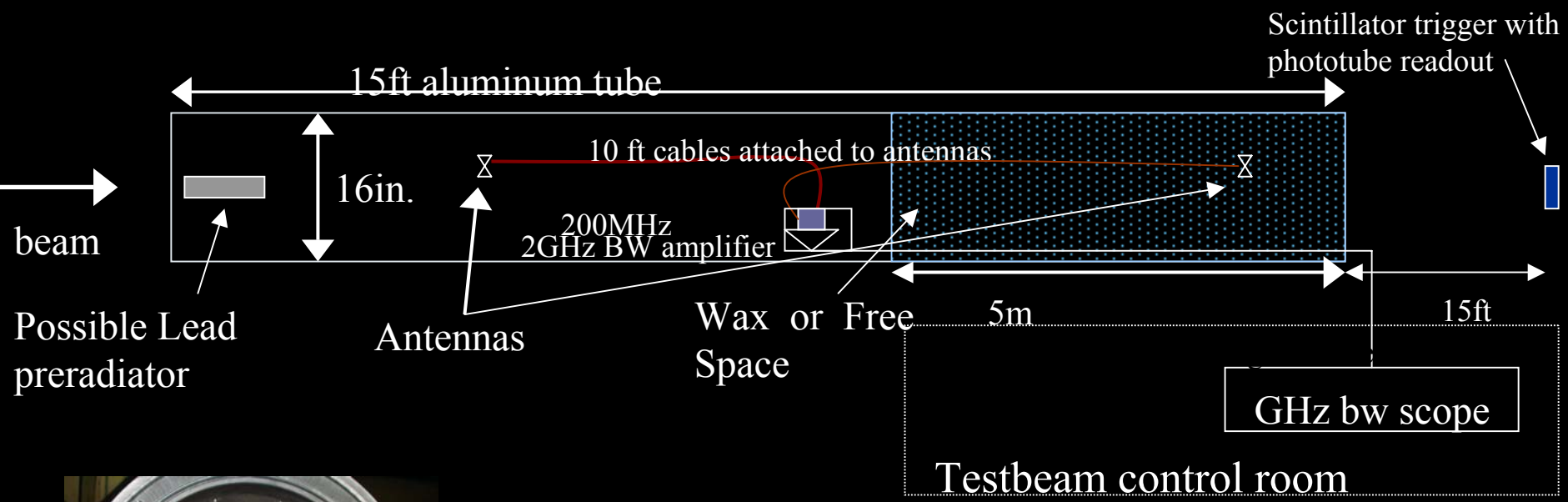
Step 2 Guesstimated signal:

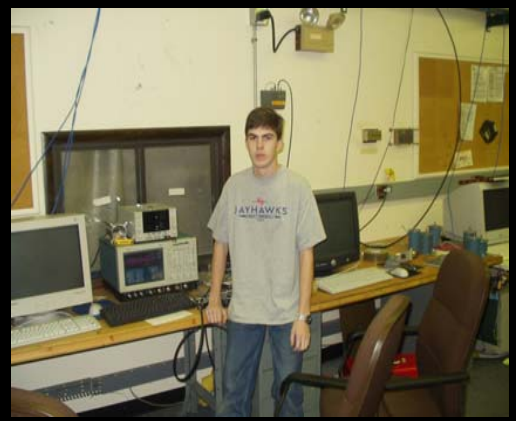
Using 2 cm distance of antennas with 1cm effective height, 500 protons at 120 GeV, amplifier gain of 300 SIGNAL SIZE O(50μV) *VERY SMALL*

Collect lots of events !

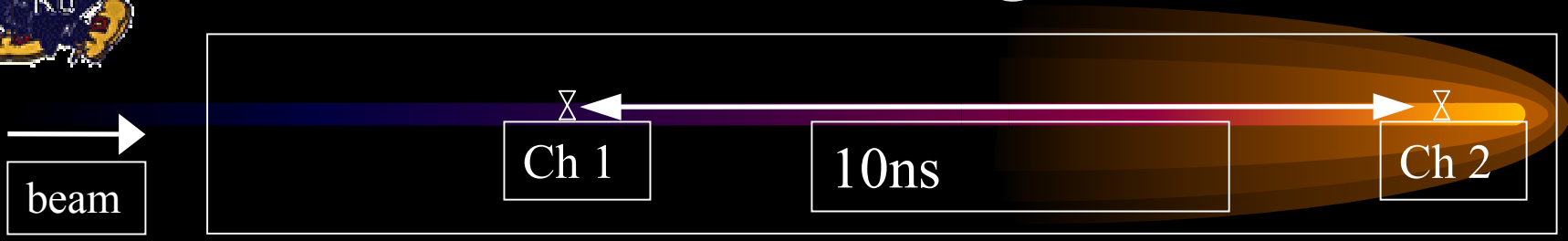
… and signal process

Testbeam setup at MTest



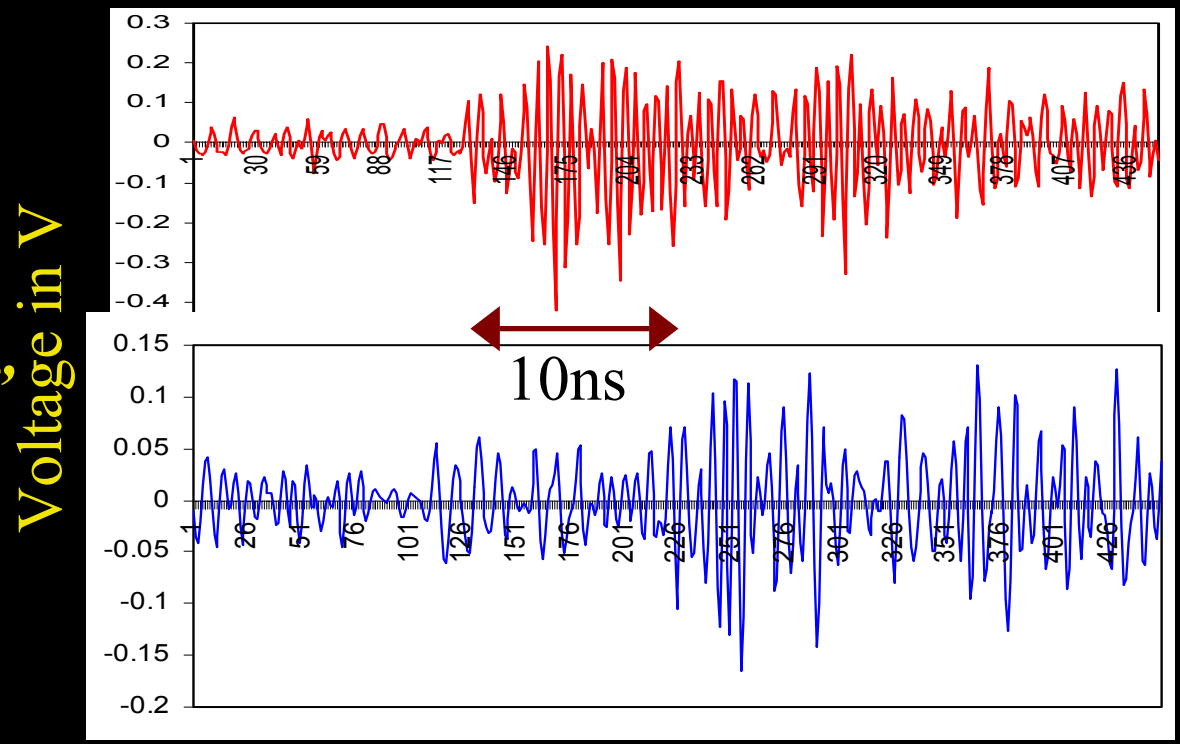


Calibration Signal



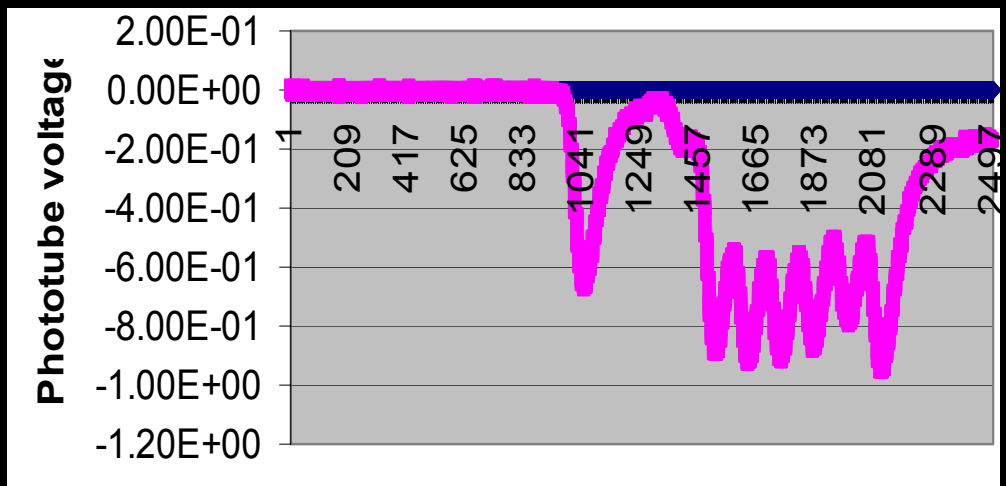
Calibration antenna signal obtained using piezo cigarette lighter (clicker)

aka "Green's function"



Run statistics

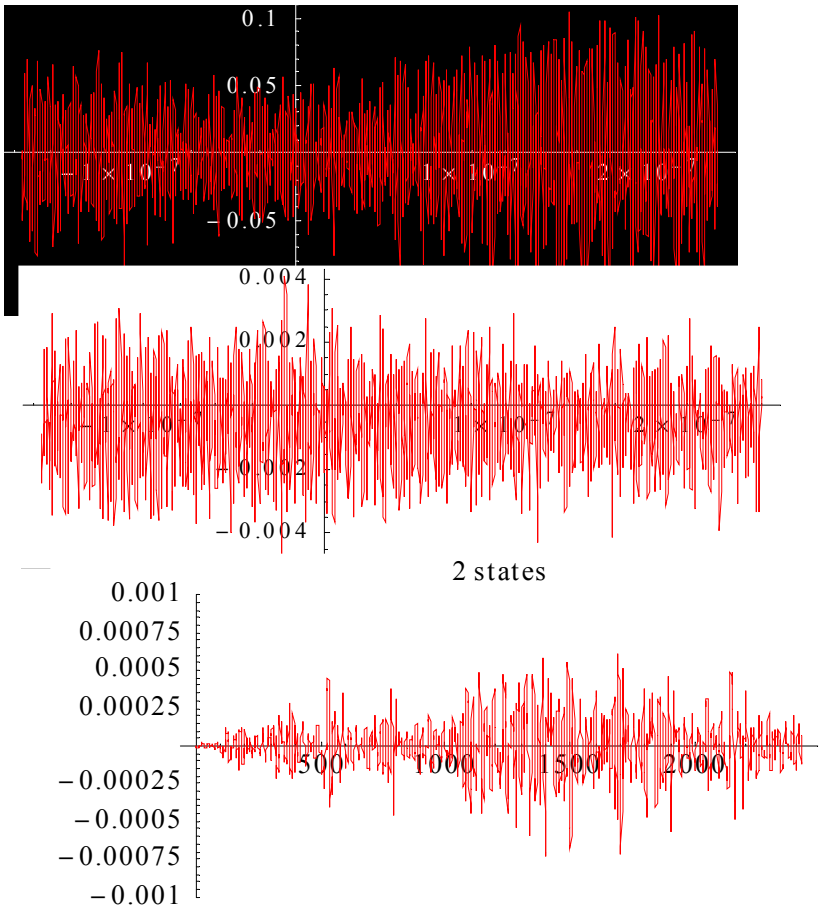
- Two run periods (integrated 45 hours) this year
- Fast spill, highest intensity allowed – 8 turns/11 buckets
- Highest intensity upstream measured around 35000 protons
- Scintillator signal estimates about 300-500 protons in first bucket (phototube at 1200V)
- Slight sequencing problem not all beam transferred



Downstream trigger scintillator scope trace

Analysis

S/N is SMALL – must use signal processing!



1. One event Noise O(30mV)

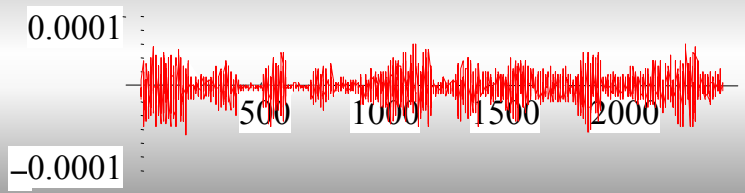
2. Average ~ 400 events
   -> reduce uncorrelated noise

   rms O(1.5mV)

3. Filter using time correlation by projecting away high node noise components (method based on Karhunen-Loeve eigenvectors)
   rms O(50μV)

Analysis (2)

Filtered Noise MC..null signal



Filtered Signal MC of one bucket

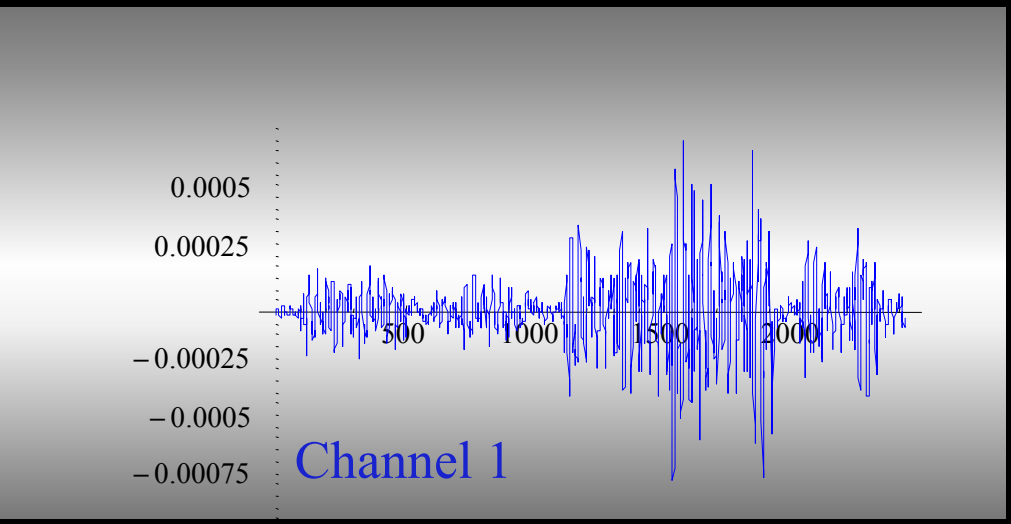
Still tuning algorithms: results preliminary

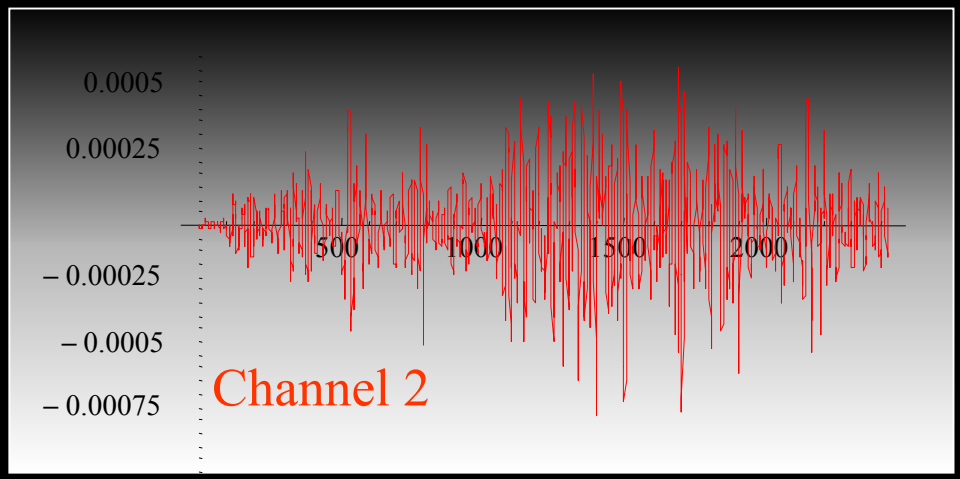
Cross-check algorithms using click and noise data as well as signal and noise Monte Carlo

Length of snippet determines time resolution

…34 points = 5.4ns

Analysis (3)





One example

Algorithm to find signal time "exists" ; time resolution depends on signal-to-noise ratios and threshold settings.

"Uncertainty Principle:"

Higher noise rejection = lower timing resolution

Summary

Radio detection "Millikan" experiment is

feasible but hard with 500-1000 protons & FNAL noise levels

Signal processing is necessary, promising, given low signal-to-noise

Work is still in progress